DETERMINATION OF PLANETARY BASALT PARENTAGE: A SIMPLE TECHNIQUE USING THE ELECTRON MICROPROBE. J.J. Papike (jpapike@unm.edu), J.M Karner, and C.K. Shearer, Institute of Meteoritics, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131-1126

INTRODUCTION: Many basaltic meteorites are being discovered in old and new meteorite suites including those from cold- deserts (e.g., Antarctica) and hot-desert environments. It is important to establish the specific planetary body source. Proven techniques for establishing planetary parentage include stable-isotopic signatures (especially oxygen), certain elemental ratios in bulk samples, and certain elemental ratios in specific minerals. Some of these techniques are expensive, require considerable sample preparation, and are adversely affected by weathering processes on the parent body or on Earth. We have been seeking key major and minor elemental ratios (in pyroxene, olivine, and feldspar) that can be measured by the electron microprobe on standard thin sections. These ratios may be preserved in unweathered portions of mineral grains and thus "see through" weathering processes. In addition, if the sample is too small to provide a representative bulk composition, it may still have key information recorded in individual minerals. We have found that some of the most useful chemical parameters are Fe/Mn (atomic) in pyroxene or olivine (Figures 1, 2) and the percent anorthite (%An) in plagioclase solid solutions (Figure 3). A plot of Fe/Mn in pyroxene and/or olivine verses %An defines compositional fields that are significantly different for Earth, Mars, Moon, 4 Vesta, and the angrite parent body (Figure 4). This method may be especially powerful when combined with oxygen isotope data.

Fe/Mn (PYROXENE, OLIVINE) VERSUS %An (PLAGIOCLASE): Previous studies have demonstrated the usefulness of major and minor elements in silicate phases to understand differences among basaltic systems and the influence of different planetary environments on basalt chemistry (e.g., Papike [1]). Intriguing data displays presented by Papike [1] include a plot of Mn vs. Fe (atoms per formula unit, afu) for pyroxene and olivine and a plot showing the anorthite content of plagioclase from different planetary basalts. Here we combine portions of these plots (Fig. 4) and provide all new data for olivine and plagioclase. This plot is based on data in the references mentioned above and in Table 1. The compositional fields represent 1 standard deviation from the mean to simplify the diagram (see Table 1 for details). Therefore, the total range of compositions is larger than the fields illustrated. Readers should realize that this data display is based on basalts. Obviously these are not all primary basalts; most reflect some cumulate effects (gain or loss of mineral phases). Therefore, this plot will be most powerful when applied to basaltic samples and will be less useful for metamorphosed basalts or cumulates. This plot shows several very interesting things about the different planetary bodies. We mentioned Mn/Fe systematics in pyroxene and olivine above. Note that olivine has a higher Fe/Mn than pyroxene. This is likely the result of high Ca in the M2 site of many of the pyroxene samples, and the preference of Mn for the M2 site of pyroxene over the M2 site of olivine. We also note the more abundant Na in Mars and Earth compared with the Moon and 4 Vesta. We did not mention the angrite parent body nor did we study angrites. Nevertheless, we thought it useful to plot the data from Mittlefehldt et al. [2] for angrites to show how different they are from other basalts, suggesting that their parent body is also very different. The angrite pyroxenes have very high Fe/Mn ratios. We do not plot the olivine because it is so different from the other basalts; angrite olivine is zoned from (Mg, Fe) olivine to Ca-olivine. Also, note that the plagioclase is practically pure anorthite. Clearly the angrite parent body is extremely depleted in volatiles compared with the others we discussed in this paper. Could the angrite parent body be Mercury?

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REFERENCES: [1] Papike (1998) *Reviews in Mineralogy* 36, 7-01 - 7-10. [2] Mittlefehldt et al. (2002) *Meteoritics and Planetary Science* 37, 345-369. [3] Papike et al. (2001) *Abstract in Lunar and Planetary Science XXXII*, #1009. [4] Karner et al. (2003a) *American Mineralogist* (in review). [5] Karner et al. (2003b) *American Mineralogist* (in preparation).

Table 1. Statistics of planetary basalt pyroxene [3], olivine [4], and feldspar [5].

Earth			Moon		
Pyx Fe/Mn	Ol Fe/Mn	An%	Pyx Fe/Mn	Ol Fe/Mn	An%
x = 40	x = 75	x = 69	x = 62	x = 103	x = 89
sd = 11	sd = 11	sd = 12	sd = 18	sd = 20	sd = 3
N = 513	N = 708	N = 474	N = 37	N = 427	N = 243
Mars			**4Vesta**		
x = 32	x = 47	x = 49	x = 30		x = 87
sd = 6	sd = 3	sd = 5	sd = 2		sd = 2
N = 33	N = 66	N = 39	N = 38		N = 35

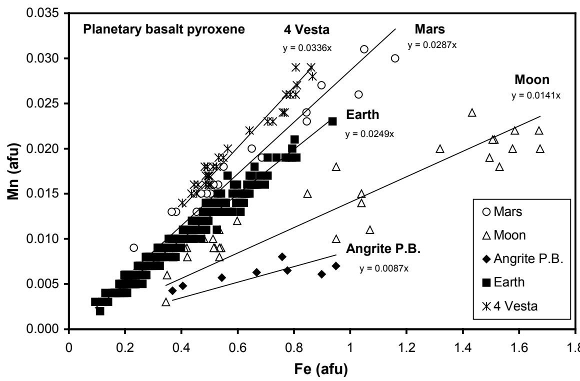

Figure 1. Mn versus Fe (afu) for pyroxene from planetary basalts. After [1],[3].

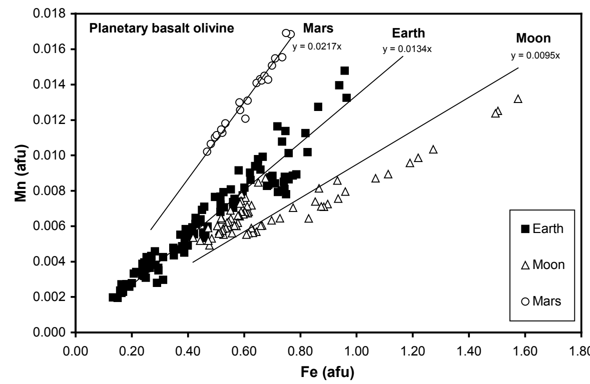

Figure 2. Mn versus Fe (afu) for olivine from planetary basalts. After [1], [4].

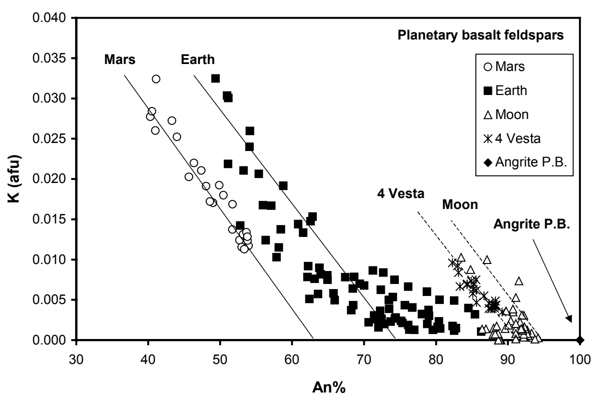

Figure 3. K (afu) versus %An for plagioclase from planetary basalts. After [1],[5].

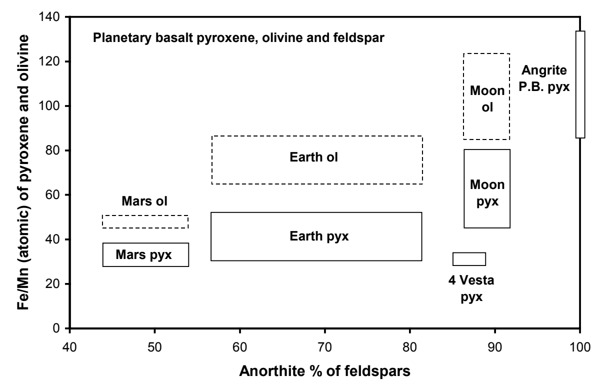

Figure 4. Fe/Mn (pyroxene, olivine) versus %An (plagioclase) for planetary basalts. Ranges in compositions represent one standard deviation from the mean. See Table 1 for details.